# ENTOMOLOGICAL NEWS

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# ENTOMOLOGICAL NEWS

VOL. L. MAY, 1939 No. 5

## Notes on Pennsylvania Flea Beetles in Tobacco Fields. (Coleoptera: Chrysomelidae).[1]

By HAROLD C. HALLOCK, Pennsylvania State College.

This discussion deals with eleven species of flea beetles found in Pennsylvania upon tobacco or upon other plants growing either in the tobacco fields or in adjoining fields. The collections were made by shaking all insects from individual plants into a net and transferring the contents to a killing jar. The material was stored in alcohol until it could be studied. During the seasons of 1937 and 1938 over 6300 flea beetles were collected.

The study was confined to three localities in Lancaster County, Pennsylvania. Approximately 60 percent of the collections were made at the Pennsylvania State College Tobacco Experiment Station where the major portion of the insecticidal tests were conducted. The Tobacco Experiment Station is located about one mile northeast of the city of Lancaster. About 25 percent of the collections were made on the farm of J. Martin Esbenshade, Jr., where additional insecticidal tests were conducted. The Esbenshade farm is about one fourth of a mile east of the Tobacco Experiment Station. Nearly 15 percent of the collections were made on Clyde Eshleman's farm where part of the 1937 flea beetle insecticidal tests were conducted. The Eshleman farm is located at Letort which is about 11 miles southwest of the Tobacco Experiment Station.

It will be noted in Table I that *Epitrix parvula* F. (tobacco flea beetle) and *Epitrix cucumeris* H. (potato flea beetle) were the important flea beetles on tobacco, although *Systena taeniata* var. *blanda* M. (pale striped flea beetle) caused some loss in

[1] Authorized for publication on February 4, 1939, as paper No. 890 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

1937 by feeding on newly transplanted tobacco. The table also points out that wheat was the only plant from which no specimens of *Epitrix parvula* were captured, even though collections were made whenever flea beetles were seen on plants growing in the immediate vicinity of these three tobacco fields. The flea beetles were observed on wheat in May and early June.

TABLE I. FLEA BEETLES COLLECTED IN VICINITY OF PENNSYLVANIA TOBACCO

| | | Number of Individual Beetles Taken on Each Plant | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Host plant | Month | prv. | cuc. | fus. | con. | pul. | pro. | blan. | fro. | bor. | vit. | bip.[1] |
| Tobacco | May | 11 | 112 | | | | | | | | | |
| " | June | 62 | 50 | | | | | 8 | | | | |
| " | July | 211 | 12 | | 3 | 12 | | 1 | | | | |
| " | Aug. | 400 | 13 | | | 2 | | | | 1 | | |
| " | Sept. | 1561 | 8 | | 2 | 1 | | | | | | |
| " | Oct. | 271 | | | | 1 | 1 | | | | | |
| Potato | May | 3 | 267 | 3 | 1 | | | | | | | |
| " | June | 15 | 759 | 9 | | 1 | | | | | | |
| " | July | 26 | 286 | | | | | 2 | | | | |
| " | Aug. | 44 | 30 | | | | | | | | | |
| " | Sept. | 91 | 149 | 2 | | | | | | | | |
| Tomato | May | 13 | 95 | | | 1 | | | | | | |
| " | Sept. & Oct. | 54 | 4 | | 1 | 6 | 1 | | | | | |
| Ground cherry | | 101 | 134 | | | 3 | 1 | | | | | |
| Morning glory | | 47 | 7 | | 144 | | | | | | | |
| Jimson weed | | 62 | | | | | | | | | | |
| Indian mallow | | 201 | 6 | | 3 | | 5 | | | | | |
| Corn | | 251 | 29 | 1 | 1 | 49 | | | | | | |
| Sweet potato | | 9 | 6 | | 33 | | | | | | | |
| Beet | | 19 | | | | | | | | | | |
| Soy bean | | 69 | | | | | | | 5 | | | |
| Wheat | | | | | 17 | 3 | | | | | | |
| Rape | | 2 | 2 | | 3 | 1 | | | | | 15 | 1 |
| Artichoke | | 29 | 2 | | 7 | | 1 | | | | | |
| Peach | | 56 | 12 | | | | | | | | | |
| Zinnia | | 27 | | | | | | | | | | |
| Plantain | | 29 | 18 | | | | | 4 | | 9 | 2 | |
| Pig weed | | 6 | 14 | | 22 | 9 | | 7 | | | | |
| Canada thistle | | 37 | 2 | | | | | 2 | | | | |
| Dock | | 13 | | | | | | | | | | |
| Burdock | | 24 | 12 | | 4 | | | | | | | |
| Hibernating under a grass mat in Sept. | | 8 | 1 | | | 2 | 6 | | | | | |

[1] par. = *Epitrix parvula* F. (tobacco flea beetle). cuc. = *Epitrix cucumeris* H. (potato flea beetle). fus. = *Epitrix fuscula* C. (eggplant flea beetle). con. = *Chaetocnema confinis* C. (sweet potato flea beetle). pul. = *Chaetocnema pulicaria* M. (corn flea beetle). pro. = *Chaetocnema protensa* L. blan. = *Systena taeniata* var. *blanda* M. (pale striped flea beetle). fro. = *Systena frontalis* F. bor. = *Dibolia borealis* C. vit. = *Phyllotreta vittata* F. bip. = *Phyllotreta bipustulata* F.

In the case of the non-economic host plants the collections were made chiefly in the fall months to determine whether the flea beetles would feed readily upon weeds, etc., when the preferred food plants were not available, so the month is not given in the table. The number of each species, which is given in the table, shows only the total number of specimens collected. The relative abundance on the host plants will be discussed under each plant. Some of the unimportant host plants will not be discussed.

*Tobacco.* The 1937-38 observations in Pennsylvania showed seven species of flea beetles feeding on tobacco but only three species were sufficiently abundant during these seasons to cause any economic loss to the growers. Under Pennsylvania conditions *Epitrix parvula* F. is the most important flee beetle on tobacco. Adults of *Epitrix parvula* were seen in the field from April 20 to November 10 yet this species did not cause extensive injury on tobacco leaves until after July 10, 1937 and the middle of August in 1938. When the adults of *Epitrix parvula* became abundant on the tobacco, the leaves were soon filled with characteristic small feeding holes.

There was a heavy migration of *Systena taeniata* var. *blanda* M. from lamb's quarters (*Chenopodium album* L.), pig weed (*Amaranthus retroflexus* L.) and Canada thistle (*Cirsium arvense* L.) to newly transplanted tobacco about the middle of June 1937. The relative abundance of *Systena taeniata* var. *blanda* on tobacco is not indicated in the table as the wilted condition of the freshly transplanted tobacco made it very difficult to collect flea beetles in any numbers.

During May and June 1938 *Epitrix cucumeris* was more abundant on tobacco than *Epitrix parvula.* While the tobacco seedlings were still in the seed beds *Epitrix cucumeris* adults made their way into the seed beds and in some cases caused extensive riddling of the young tobacco foliage. When the tobacco was transplanted in 1938 there was a heavy migration of *Epitrix cucumeris* to the newly set tobacco plants. The feeding of *Systena taeniata* var. *blanda* in 1937 and *Epitrix cucumeris* in 1938 on newly transplanted tobacco caused heavy

loss to the Pennsylvania growers as the flea beetles riddled the leaves and destroyed the growing tip of the young tobacco plants. As a result of this feeding many young tobacco plants died and the growers were forced to reset a larger number of plants than usual and in some cases secured a rather uneven stand of tobacco.

Published records fail to show that *Systena taeniata* var. *blanda* has previously caused severe injury to the tobacco crop. Although Duckeet (1920) did not mention tobacco in his list of food plants of *Systena taeniata* var. *blanda* he gave a wide variety of food plants. These facts lead to the conclusion that *Systena taeniata* var. *blanda* is likely to attack tobacco only when it is unusually abundant in the vicinity of tobacco fields as occurred in June 1937.

Morgan and Gilmore (1924) and Schoene and Underhill (1937) pointed out that *Epitrix parvula* is the important flea beetle pest of tobacco in the south. Lacroix (1935) stated that *Epitrix cucumeris* is one of the most important tobacco pests in Connecticut.

*Potatoes.* It has been pointed out in the table that six species of flea beetles were observed on potatoes during the 1937-38 seasons, but only *Epitrix cucumeris* and *Epitrix parvula* were abundant. Adult beetles of *Epitrix cucumeris* were observed upon potatoes nearly as soon as the potato tops appeared above ground in the spring and remained an important pest until fall. It is interesting to note that *Epitrix parvula* was scarce on early potatoes but became more common during July and continued numerous during August and September. It was not unusual in these fields during the period from August 20 to September 15 to find that 50 to 70 percent of the flea beetles on the potatoes were *Epitrix parvula.*

**(To be continued)**

# The Significance of the Two Types of Larvae in Sphecophaga burra (Cresson) and the Factors Conditioning Them (Hymenoptera: Ichneumonidae).

By Rudolf G. Schmieder, Zoological Laboratory, University of Pennsylvania.

In the ichneumonid wasp, *Sphecophaga burra* (Cresson), eggs laid upon the same host presumably by the same mother and under the same conditions of the physical environment may develop into either one of two distinct types of larvae. One of these spins only a delicate, white cocoon within which it develops forthwith into the imago; the other spins a tough, brown cocoon, and, before transforming, undergoes an extended diapause, normally lasting through the fall and winter, before it too pupates and finally emerges.

These facts, recorded in a recent paper (Schmieder 1939), raise the question of the significance of these two types of individuals and also the question of the nature of the determining factors that condition their production.

## Significance in Survival

The idea that the individuals that spin the brown cocoons represent the typical form of the species (loc. cit. p. 94) finds further support from the fact that, of the two kinds, they are better adapted to survive the winter and therefore it is they, that could, if present to the exclusion of the other sort, still preserve the existence of the species.

The larvae that spin the white cocoons represent then a special type of individual with a shorter life history. Their significance, at least in regard to the survival of the species, is quite evident. They represent forms that emerge within about a week after spinning and can, no doubt, immediately give rise to another generation. A succession of such short generations occurring through the summer will effect a great increase in the numbers of the parasite.

In many insects, a succession of short summer generations is followed by a long, overwintering generation. In *Sphecophaga,* however, each generation produces larvae that transform

immediately as well as larvae that undergo a diapause, so that we have to do with an even more effective device for ensuring survival of the species. If, let us say, a single parasite finds a hornet's nest in which to oviposit, that parasite will, of course, have daughters (in white cocoons) which emerge forthwith and in turn give rise to several generations of the same kind through the summer. However, this same original parasite will also have other daughters (in brown cocoons) which will not emerge until the following summer. These ensure that our parasite will be represented by offspring in the following season even if conditions during the present season should become unfavorable and the "white" daughters die without progeny.

There is still another device assuring the survival of *Sphecophaga*. In *S. vesparum*, some of the larvae occupying brown cocoons remain in diapause only until the following spring, when they transform to emerge as adults; others remain in diapause through a second and even through a third winter before transforming (Semichon 1908). Thus the offspring are distributed in time of emergence through several seasons, increasing the probability that some at least will encounter a favorable season.

### Determining Factors.

In regard to the determining factors that condition the production of larvae that spin white cocoons rather than larvae that spin brown cocoons, nothing is as yet known. In the years since my first observations were made I have frequently sought to obtain additional material with which I hoped to breed these parasites in the laboratory and possibly discover the factors involved. Of many nests taken only the two from Media, Pennsylvania, yielded any parasites at all, and those only seven cocoons. Of four parasites that emerged, two were lost. From the remaining two I attempted to secure offspring in the hope of developing some practical method of breeding the species for experimental purposes. I confined the two female *Sphecophaga* in large Comstock vials together with parts of combs containing pupae of yellowjackets, *Vespa* sp., from an under-

ground nest; also with exposed pupae from the same nest and with exposed and with cocoon-enclosed diapause larvae of the mud-dauber, *Sceliphron caementarium* Drury. In no instance was oviposition observed or were any parasitic larvae seen.

In the absence of workable experimental procedures, there remains only the possibility of attempting an analysis of the observational data at hand. The following table records the contents of each parasitized hornet's cell studied.

TABLE I

| No. of parasites per host cell | No. of cells | No. of cocoons in each cell | |
|---|---|---|---|
| | | brown | white |
| 1 | 10 | 1 | 0 |
| | 2 | 0 | 1 |
| 2 | 14 | 2 | 0 |
| | 2 | 1 | 1 |
| 3 | 8 | 3 | 0 |
| | 3 | 2 | 1 |
| | 1 | 1 | 2 |
| | 1 | 0 | 3 |
| 4 | 1 | 4 | 0 |
| | 1 | 3 | 1 |
| | 2 | 2 | 2 |
| | 1 | 0 | 4 |
| 5 | 4 | 2 | 3 |
| | 1 | 3 | 2 |
| | 1 | 0 | 5 |
| 6 | 1 | 3 | 3 |
| 7 | 1 | 3 | 4 |
| Totals | 54 | 99 | 47 |

From it certain generalizations can be made regarding the occurrence of the white cocoons: 1) They occur least frequently in those cells that harbor less than three cocoons. For example, there were twenty-eight cells that contained only one or two cocoons each. In these twenty-eight cells there was a total of forty-four cocoons of which only four were white cocoons, that is 9%. 2) The white cocoons occur more frequently in cells having more than three cocoons each. Five cells with four parasites each yielded nine out of twenty, or 45% white cocoons. Six cells with five parasites each yielded nineteen out of thirty, or 63% white cocoons.

From these generalizations and from a further study of the cells containing four or more cocoons we may be justified in

concluding that: In cells harboring two or three brown cocoons, any additional cocoons present are more apt to be white cocoons than we should expect on a purely chance basis. Or, to put it another way: After several "brown" larvae have fed upon a given host, any additional larvae present are more apt to spin white cocoons.

Several years after first encountering *Sphecophaga* I began to study the biology of the chalcid-fly *Melittobia chalybii* Ashmead, and discovered in that species polymorphic forms which differed from each other not only morphologically but also, as do the two larval types of *Sphecophaga,* in the length of their life-histories (Schmieder 1933). In *Melittobia,* the larva of the type-form individual undergoes, even if kept at 25°C., a diapause lasting more than two months while the larva of the second-form adult, in the absence of a diapause, transforms immediately into the imago. The fact that in both *Melittobia* and in *Sphecophaga* there occur larvae with, as well as larvae without, an obligatory diapause suggests that a comparison of the phenomena encountered in these two insects may possibly yield evidence as to whether the determining factors that are known to be operative in *Melittobia* are also effective in *Sphecophaga.*

In *Melittobia* it has been shown (Schmieder 1933) that the production of one or the other of the two forms is determined by the trophic conditions obtaining during the larval growth period. A single host (e. g., *Trypoxylon* or *Sceliphron*) provides sustenance for from 500 to 800 larvae of this minute parasite. Not more than twenty of these, the first twenty, give rise in two weeks to "second-form," brachypterous females and eyeless males. All the hundreds of larvae that develop after these first twenty give rise, after a long diapause, to adults of the type-form.

In other Hymenoptera also, and indeed, among insects generally, trophic factors more frequently than any others are found to be the mechanism that conditions polymorphism. Upon *a priori* grounds it is then most probable that in *Sphecophaga* likewise trophic differences will be found decisive.

It may be that the mechanism for determination resembles that found in *Melittobia* and depends upon some quality in the food ingested by the larvae. The first few *Sphecophaga* larvae that feed upon a given host may take up largely the blood of that host while those that are somewhat retarded will have to ingest more of the fat-body and the urates stored therein. This view, which seems quite plausible, finds support in observations made by Reichert (1911) on *S. vesparum.* Reichert alone of those who have written on this species reports finding thin white cocoons along with the typical brown ones. From one nest he records seventy-eight brown cocoons and five white ones. The white ones, the "Kümmerformen," he believes result from undernourishment of the larvae and give rise to dwarf imagines. The dwarfs he obtained were only 2.25 mm. long compared with the largest giants, 8.5 mm. in length, from the brown cocoons. He also found cocoons intermediate in appearance between the normal and the starved kinds.

The dimorphism in *S. vesparum* in which absolute undernourishment produces white cocoons and in which intermediates between brown and white cocoons exist, would seem to represent an earlier evolutionary stage that finds its full development in the more definite dimorphism of cocoons, without evident undernourishment and without intermediate forms, in *S. burra.* In other words, the dimorphism in *vesparum* is imperfectly developed and differentiation is in proportion to the food supply; in *burra,* differentiation depends, probably, on which one of two inherently possible lines of development is stimulated by a difference in some quality of the food encountered by the larva at some critical period.

In regard to *S. vesparum,* it should be mentioned that, at least in England (Morley 1911), it exhibits a true dimorphism. In addition to the usual winged forms there occur brachypterous individuals. The latter, Morley suggests, represent a summer generation that emerges and oviposits in the same, still fully tenanted wasps' nest. Morley's descriptions of the cocoons also differ from those of continental authors, as does the absolute size of his specimens.

The sub-optimum trophic conditions that, as has been suggested, act at some critical period upon the larva to direct development along that alternative path leading to a white rather than to a brown cocoon may, of course, be due to other factors than the effect of the depletion of food by sister parasites. They may be due to differences in the parts of the body of the host upon which the individual parasites feed resulting, for example, in some individuals ingesting more urates than others. Or, if we consider that, in at least a few cells, white cocoons only were found, they may be due, occasionally, to the stage of development of the host, or to some other condition that affects all parasites in a given host cell equally.

Finally, it should be kept in mind that differentiation into one of the two possible types of individuals may take place as early as the ovarian egg. That differentiation may occur so early in ontogeny is shown in *Melittobia,* in which of the many eggs obtainable from unmated females ordinarily only 3% are capable of development (Schmieder 1938). In *Sphecophaga,* the observation that white cocoons appear more commonly in host cells containing a larger number of parasites would suggest that rapid egg-production yields a larger number of "white" individuals, while a slower egg-production, or longer retention of eggs in the ovary, has the opposite effect.

As long as we know nothing at all of the oviposition habits of *Sphecophaga,* and so very little of the life of the early larva, it is not possible to come to any definite conclusion as to the conditioning factors responsible for the dimorphism of the cocoons. More observations are needed and experimentation will also be necessary. It is desirable that anyone wishing to contribute to our knowledge of *Sphecophaga* have the entire problem clearly in mind so that when a populous and well parasitized hornets' nest becomes available the necessary observations can be made immediately and appropriate experiments undertaken without delay while the early stages of the parasite, including the eggs, are still available. Meanwhile, on the basis of the observations presented in this paper and the comparisons made between the conditions encountered in this

insect with those obtaining in such polymorphic species as *Melittobia,* I feel justified in proposing the tentative hypothesis that: Trophic factors acting upon the larvae condition the determination of *S. burra* individuals into brown cocoon-and white cocoon-spinning forms, of which only the former undergo a diapause.

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## Terias palmyra Poey (Lepid.: Pieridae).

*Terias palmyra* Poey, has not as yet been included in any list of North American butterflies. In Seitz, Vol. V. page 84, is this statement. "*Palmyra* Poey, (= lydia, Fldr.) from Cuba and the Gulf States," etc., etc.

In August 1908 I received from the late W. S. Dickinson, of Miami, Florida, who sent me his season's catch for several years, a male specimen of *Terias* which Mr. Watson, of the American Museum of Natural History, identified as *T. palmyra* Poey. He dissuaded me from announcing it on the grounds that I had not taken it myself.

I have recently received from Mrs. L. E. Forsyth, of Florida City, Florida, a female specimen of *palmyra,* taken by her on Key Large. Both specimens are in my collection.

W. C. WOOD, Mahopac, New York.

## Conostethus americanus new species from Colorado, Montana and South Dakota (Hemiptera, Miridae).

By HARRY H. KNIGHT, Iowa State College, Ames, Iowa.

The genus *Conostethus* has not before been reported from North America, although four species are known in Europe. The genus is peculiar in having the third antennal segment permanently curved downward, also in the anteriorly curved front tibiae. The relative lengths of the antennal segments appear to give distinctive characters for separating the species. In the present study the writer has given careful consideration to descriptions of the European species, also having a specimen of *C. salinus* Sahlb. for comparison.

**Conostethus americanus** new species.

Allied to *salinus* Sahlb., but distinguished by structure of the antennae; segments II and III subequal in length, the male with long hairs on the ventral surface of segment III.

♂. Length 4 mm., width 1.1 mm. Head: width .82 mm., vertex .43 mm.; vertex twice the dorsal width of an eye. Rostrum, length 1.12 mm., just attaining base of hind coxae, pale, the apex black. Antennae: segment I, length .39 mm., thickness .13 mm., black, finely pale pubescent; II, .99 mm., thickness .08 mm., slightly thicker apically, black, pale pubescent; III, .99 mm., thickness .06 mm., distinctly decurved, ventral surface with long pale pubescence, length of hairs exceeding diameter of segment, black; IV, .48 mm., black. Pronotum: length, .47 mm., width at base .99 mm.; basal margin slightly sinuate, lateral margins strongly sulcate sinuate, basal angles produced and slightly reflexed; disk moderately convex, glabrous, black, margins and median line pale, calli distinctly convex. Scutellum fuscous to black, median line pale; mesonotum exposed, fuscous, a pale area on each side.

Hemelytra reaching beyond apex of abdomen, pale translucent, corium and clavus shaded with fuscous, membrane uniformly pale fuscous. Thorax chiefly fuscous, venter fuscous to black, lateral margins greenish yellow. Legs pale to dusky,

base of coxae blackish, hind femora with fuscous above, front and middle femora with a few fuscous dots on posterior aspect; tibiae pale, spines black, front pair strongly curved, the convexity on the dorsal side; tarsi fuscous, pale on basal half.

♀. Length 3.9 mm., width 1.2 mm. Head: width .82 mm., vertex .45 mm.; vertex more than twice the dorsal width of an eye. Antennae: segment I, .30 mm., fuscous to black; II, .86 mm., cylindrical, black; III, .86 mm., more slender than II, slightly curved, black; IV, .47 mm., black. Pronotum: length .47 mm., width at base .95 mm., margins sinuate as in the male. Slightly more robust than the male and paler in color. Head pale, frons with transverse dark lines, base of head, sinuate line on vertex between eyes and spot on base of tylus and apex of frons, blackish. Hemelytra fully developed, paler than in the male, the fuscous shading nearly obsolete. Ventral surface pale to greenish; legs pale, a few dusky points evident on posterior aspect of femora, tips of tarsi black. Front tibiae only very slightly curved.

*Holotype:* ♂ May 20, 1899; Fort Collins, COLORADO (E. D. Ball); author's collection. *Allotype:* June 2, 1899, Fort Collins, COLORADO (E. D. Ball). *Paratypes:* ♀ May 24, ♂ ♀ May 20, 1899, Fort Collins, COLORADO (E. D. Ball). 2♂ "Colo. 4421." MONTANA—2♂ 9♀ June 20, 1938, Huntley (Wm. Forsyth). SOUTH DAKOTA—♂ 3♀ June 1, 1921, Capa; 2♂, 2♀ May 12, 1922, Capa (H. C. Severin).

## Why Study the Senses of Insects?

By CYRIL E. ABBOTT, Harding College, Searcy, Arkansas.

If, tomorrow, someone should discover an eyeless butterfly that frequents flowers, it would be possible to describe, without even seeing a specimen, certain pecularities of the species. It would be found to possess large and peculiarly modified antennae and palpi. One, perhaps both of the sexes, would have well developed scent glands. It might have tympana. It would be modest in coloring. It would fly on dull days as well as sunny ones; it might even fly at night. Mating would take

place as a result of olfactory stimuli, and there would be no elaborate courtship. For the bionomics and behavior of a given species of insect depends upon its sensory equipment, so that the insect lacking in one sense has at least one of the others highly developed. At least this is true of terrestial and aerial insects.

For example, insects which have high visual acuity generally have poorly developed chemical senses and *vice versa*. Although, generally speaking, the Diptera and many Hymenoptera are exceptions to this statement, there are exceptions even to these exceptions. Thus the Asilidae give little evidence of olfactory powers, while the poor eyesight of ants is well known. Insects with auditory powers often have weaker vision than those that do not. The Noctuidae, which have tympana, have lower visual acuity than the deaf Sphingidae. Thus one is entirely justifiel in making the statement that, given a complete analysis of the senses of a given insect, he can, within reasonable limits, predict the behavior of that species.

The extent to which behavior may be analyzed is excellently illustrated by predatory insects with binocular vision. Because it is necessary for the compound eyes to be simultaneously in use to fix the position, and especially the distance of its prey, the predator must be able to move its eyes, its head, or its entire body very quickly. Since the eyes of insects are fixed, predatory insects either have highly mobile heads (mantids, dragonflies, and certain Hymenoptera) or are able to move the whole body very quickly.

Incidentally, the necessity of binocular vision for the capture of prey is easily demonstrated by covering one eye of a mantis with opaque varnish. Although the animal so treated will "strike" at flies and other moving objects, its "aim" is so poor that any success it enjoys is the result of accident, so that unless relieved, it will starve to death in the midst of plenty.

The behavior of predators without mobile heads is illustrated by the behavior of the Cincindelidae. These beetles make their captures by means of a "head on" rush. When pursued, the tiger beetle generally alights facing its pursuer, for it is in

this way only that it can determine the distance of its enemy.

A study of insect senses enables one to interpret behavior complexes. Why is it practically impossible to induce butterflies to mate in captivity? Because butterflies, depending as they do upon vision for the majority of their sensuous stimuli, mate during, or soon after, flight. Moreover their mating is preceded by a complex courtship which seems to depend, again, chiefly upon visual stimuli. This probably accounts in part for the brilliantly distinctive markings of butterflies. Mating involves not only recognition of the opposite sex, but also of the appropriate species. That this recognition is imperfect is revealed by the frequency with which males of one species attempt to mate with females of a similar species. Moths, on the other hand, perhaps because they are mostly nocturnal, depend upon their chemical sense for the selection of mates. All this indicates that one need invoke neither "instinct" nor a "physico-chemical mechanism" to describe and interpret behavior; a knowledge of the senses involved, combined with a little common sense, are all that are required.

A knowledge of insect senses enables one to indicate the origins of such behavior. For countless generations dragonflies have started life as aquatic animals. Even the adults are sensitive to water vapor, while their great eyes are doubtless responsive to the light reflected from extensive water surfaces. Is it any wonder, then, that the female dragonfly, in spite of her aerial habit, deposits her eggs in the water? The adult cabbage butterfly (*Pieris rapae*) does not feed upon cabbages, but that does not prevent the female from being sensitive, both visually and chemically, to cabbages, to the extent of depositing her eggs thereon.

Even developmental processes may be interpreted on the basis of changes in the sensory equipment of the insect. The larvae of *Gyrinus* have filamentous antennae, while in the adult the antennae are highly modified, "shoe-shaped" structures. The submerged larva depends upon vision plus, possibly, a chemical sense, for the capture of its prey. The adult beetle seldom leaves the surface of the water excepting to escape enemies. It de-

pends upon vibrations of that surface both for the capture of prey and the avoidance of enemies; vibrations transmitted through specialized chordotonal organs located in the antennae. The antennae of the adult also warn it of its approach to any large object projecting from the water, so that it may avoid collision with the same.

Obviously senses are correlatel with the morphology, physiology, and ecology of the insect. The eyes of dragonfly larvae which inhabit the muddy river bottom are rather different from the eyes of those clinging to water plants. Some surface-inhabiting Hemiptera have the ommatidia on the dorsal surfaces of the eyes smaller and more numerous than those on the ventral surface. Doubtless the visual acuity of the dorsal area is greater than that of the ventral portion.

A study of insect senses enables one to help control noxious species. The destruction of the Japanese beetle through traps baited with geraniol and the killing of houseflies through the attractive yet toxic action of formaldehyde are familiar proofs of the efficacy of such knowledge. On the other hand, I have seen blowflies alight upon meat dipped in a formalin solution strong enough to prove irritating to the onlooker.

The possible effects of irritants upon insects has not received sufficient attention. It has been my observation that mosquitoes are repelled chiefly by irritants. It is a recognized fact that heat radiation alone is sufficient to initiate the feeding responses of mosquitoes. In view of this, a great number of substances which are noisome merely, and which have been generally recommended as repellent, are totally inadequate as protection against mosquito attacks. (The best repellent to date appears to be pine tar mixed with an equal quantity of tallow. Though slightly irritating to the human skin, it is not dangerous or unduly uncomfortable to use. Besmeared with this substance I have slept unannoyed and safe although surrounded by mosquitoes!)

In contrast to the mosquitoes, the stable fly, (*Stomoxys calcitrans*) does not respond to heat radiation, but to the odor of perspiration, so that a merely malodorous repellent may prove effective against this species.

In answer, then, to the query as to value of the study of insect senses, one might reply: "He who is thoroughly acquainted with the morphology anl physiology of the sense organs of a given species of insect, is thoroughly acquainted with that species of insect."

## Observations on Parasitism and Superparasitism (Lepid.: Sphingidae; Hymen.: Braconidae, Chalcididae).

By C. Brooke Worth, Swarthmore College, Swarthmore, Pennsylvania.

In September, 1938, I found a catalpa tree (*Catalpa bignonioides* Walt) at Swarthmore, Pennsylvania, infested with caterpillars of the catalpa sphinx, *Ceratomia catalpae* Boisduval. More than half of the caterpillars were doomed, bearing variable numbers of cocoons of the braconid wasp, *Apanteles congregatus* Say.

At random, I collected twenty-three caterpillars fourteen of which already bore braconid cocoons. Subsequently five more "broke out" with braconid larvae, so that only four of the original twenty-three were unparasitized. This survival rate for the sphinx caterpillars, 17%, might have been still lower, had the four unparasitized ones not been protected from wasps during their last caterpillar days in my vivarium.

The nineteen parasitized caterpillars brought forth a total of 1346 braconid cocoons. These were distributed among the host caterpillars as follows:

| Host No. | No. Cocoons | Host No. | No. Cocoons |
|---|---|---|---|
| 1 | 2 | 11 | 57 |
| 2 | 10 | 12 | 59 |
| 3 | 11 | 13 | 59 |
| 4 | 19 | 14 | 60 |
| 5 | 23 | 15 | 64 |
| 6 | 38 | 16 | 65 |
| 7 | 42 | 17 | 83 |
| 8 | 45 | 18 | 113 |
| 9 | 51 | 19 | 295 |
| 10 | 52 | Dropped off | 198 |
| | | Total | 1346 |

These cocoons yielded approximately equal numbers of braconid wasps (kindly identified for me by Mr. Hopper at the Academy of Natural Sciences) and superparasites belonging to the family Chalcididae.

The average degree of infestation is 71 cocoons per caterpillar, but the mean, in the actual cases, falls closer to 60. I suspect on the basis of these figures that the average *A. congregatus* female lays about sixty eggs within the sphinx caterpillar. If this be so, caterpillar No. 18 was parasitized by two wasps, while No. 19 was the victim of no less than five.

The cocoons were usually disposed laterally on the caterpillar, the larvae boring their way out along the line of the spiracles. In cases of very heavy infestation, the dorsal surface of the host also bore an abundance of cocoons. The ventral surface was always free of them.

The emergence of the larvae was always attended by great loss of "blood" in the hosts. They seemed never to recover from the shock, becoming very sluggish, and appearing weak and deflated. About half died before their burden of cocoons hatched; the other half were still alive, technically speaking, at this time but were unable to move. All the caterpillars died *in situ*, that is, clinging to a midrib or large vein on the ventral surface of a leaf; this circumstance is probably essential to the successful hatching of the cocoons.

The cocoons hatched about a week after the wasp larvae had emerged from the caterpillars. The hatching wasps cut the tops off the cocoons very neatly, producing perfect hemispherical lids which remained attached at one point by a few silken strands. Once able to lift the lid, a wasp would fairly burst out of its cocoon, running actively about the vivarium at once and very shortly taking flight.

Among the *Apanteles* wasps there were equal numbers of males and females. One could therefore expect 336 females to be on the look-out for young catalpa caterpillars in the summer of 1939. The chalcids, however, were all females, presumably experiencing a parthenogenetic generation in September. There would therefore be twice as many females of this species (that

is, 673) on the look-out for *parasitized* young catalpa caterpillars in the summer of 1939. We may suppose, casually, that it is twice as hard for this species of chalcid to fulfill its life cycle as it is for the braconid species, for the chalcid's search for a properly prepared place to lay its eggs is more highly specialized.

The four unparasitized catalpa caterpillars in my vivarium died. Had they lived, and had half of them been females (which is the most reasonable assumption), each of the two potential mothers would have to lay 202 eggs in 1939 (for 336 would fall prey to braconids, and only 17%, or 69, would survive).

But if these two females left 69 surviving descendants in 1939, the population of caterpillars would be increasing at the rate of 1625% per year. The same reasoning would account for a similarly great increase of braconids and chalcids. It is safe to predict that no such thing will occur.

We have assumed that all the wasps will be on hand next summer and that for this reason the moths will have to lay a large number of eggs. If we were to eliminate some of the wasps, the moths would not have to be so reproductive. During the winter the wasps conceal themselves in crevices of the bark of trees and in other such hiding places. A brown creeper, the stomach of which I examined in midwinter, contained an abundance of fresh insect remains; it is likely that hibernating wasps will be consumed by creepers, nuthatches, titmice, and other small insectivorous birds. In Fall and Spring many are probably caught in flight by swallows, flycatchers, and swifts, while some undoubtedly end their lives miserably in spiders' webs. A few others may fail to find a suitable colony of caterpillars to parasitize, or they may not find mates at the proper time.

The question arises: how extensive is this decimation of braconids and chalcids? Returning to the catalpa moths for the answer, let us stabilize their population by allowing them neither to increase nor decrease during the coming season—this time next year there must be only four surviving caterpillars from any four pupae which are safely underground now. If the braconids parasitize the same percentage of larvae next

summer as in 1938, the four surviving larvae in 1939 will have to witness the parasitization of 19 of their siblings. This means that each female pupa in the ground at present will have to lay 12.5 eggs next Spring in order to ensure the production of one female descendant which will survive the onslaughts of braconids.

Allowing this figure to stand for a moment, we see that this is only 5.7% of the number of eggs the moths would have had to lay to satisfy the braconids, had *they* all survived. This means that 94.3% of the 1938 braconids will have to be destroyed before the summer of 1939 if the populations of both moths and wasps are to remain constant.

The moths, however, will lay more than 12.5 eggs apiece. It must be presumed, therefore, that the race of *C. catalpae* experiences lethal environmental factors other than parasitism by braconids. An excess of individuals must be provided for destruction by other agencies, which might include parasites of the eggs, eaters of eggs and caterpillars (such as birds), bacterial and other diseases of the caterpillars, shortage of food supply (as when a tree becomes defoliated), accidents to the pupae, and destruction of imagines before mating or completion of egg laying has occurred.

It would be interesting to count the exact number of eggs laid by *C. catalpae,* to find what proportion of their reproductivity is essential to sustaining the braconid population. This figure is represented by the fraction:

$$\frac{12.5}{\text{Number of eggs}}$$

## Conclusions.

1. In a single case, caterpillars of *Ceratomia catalpae* were parasitized by *Apanteles congregatus* to the extent of 83%.
2. In a single case, larvae of *Apanteles congregatus* were parasitized by a species of Chalcididae to the extent of 50%.
3. *Apanteles congregatus* usually lays about 60 eggs.
4. The mortality of *Apanteles congregatus,* before completing the reproductive cycle, is estimated at 94.3%.
5. The species of Chalcididae mentioned is estimated to a)

experience a mortality twice as great as that of the braconid, or b) lay only half as many eggs, or c) lay half its eggs in caterpillars which have not been parasitized by braconids, or d) be partially eliminated in some other way.

6. The braconid scourge is only a small part of the mortality experienced by *C. catalpae* in the various stages of its metamorphosis.

## A Note on the Fabrician Species lycaste (Lepidoptera: Ithomiinae).

By Richard M. Fox, Academy of Natural Sciences of Philadelphia.

Recently I was confronted with the perplexing problem of the identity of the species *lycaste* Fabricius[1]. Since this name has been a source of uncertainty and controversy, it might be well to review here its history and synonymy, and to record my conclusion regarding the form which Fabricius intended to describe.

The original description is ambiguous and, as Dr. Holland pointed out[2], "might apply to a number of species." The following is my translation of the Latin text:

"P(apilio) H(elliconius lycaste). The elongated wings completely tawny to the black apex: forewing with a golden yellow maculation. Figured by Jones, II, pl. 7, fig. 1 as Papilio lycaste. Habitat (unknown). In Drury's private collection (*Mus. Dom.*). Small. Head black, spotted with white. Thorax tawny. Abdomen ashen. Forewings tawny at the base with a black median spot, followed by bright yellow, the black apex with several yellow spots. Hindwings tawny with a black apex."

According to Butler[3] South American specimens from Mr. Milne's collection were associated in the British Museum with the name *lycaste*. Reference again is made to the Jones drawing, "This species is figured in the unpublished 'Icones' of Mr.

[1] Fabricius, Ent. Syst., III, p. 161 (1793).
[2] Holland, Butterfly Book, revised edition, p. 72 (1931).
[3] Butler, Cat. Fab. Diur. Lep. B. M., p. 126 (1869).

Jones, now in the possession of F. Dawtry Drewitt, Esq., Christ's College, Oxford." In the preface to the same work, J. E. Gray said[4], "The Museum, also contains, by purchase at Milne's, Strothard's and other sales, several specimens which originally formed parts of Mr. Drury's collection and are types from which Fabricius described other species . . . Fabricius described some hundred species from a series of drawings made chiefly from his own collection by the late Mr. Jones of Chelsea . . . Fabricius always quoted these drawings as Jones's 'Icones.' They were formerly lent to the Museum and Mr. Doubleday named part of the Museum collection from them . . . notes and sketches were made from them for the use of this 'Catalogue,' thus enabling the Museum specimens to be named from a comparison of the original drawings."

To that time there seemed to be little doubt in the minds of students as to the identity of *lycaste*. But as collections grew, the Ithomiinae came to be recognized as a confusing complex of similarly marked species, and the brief Latin descriptions by the early workers no longer were sufficiently precise. Reakirt attempted to further illuminate *lycaste* and to throw into relationship with it various forms then recently described by continental authors[5]. His description of "typical *lycaste*," however, is that of a male *panamensis* Bates[6]. Subsequent authors, including Kirby, Scudder, Haensch and others, followed Reakirt in his error.

Dr. Holland published on plate VIII of the "Butterfly Book" a figure concerning which he says in the revised edition[2]: "In the first edition of this book this insect was named *"Ceratinia lycaste* Fabricius." At the time I hastily accepted Reakirt's determination as correct, but long since discovered my mistake. The insect which Reakirt called *lycaste* Fab. and attributed to California, is undoubtedly *Ithomia anaphissa* H.-S.[7], a Central American insect." It is curious to note that Reakirt's determination did not agree with his own description.

[4] Butler, op. cit., pp. iii-iv.
[5] Reakirt, Proc. Ent. Soc. Phila., V, pp. 218-222 (1865).
[6] Bates, Proc. Zool. Soc. Lond., p. 244, pl. 29, f. 5 (female) (1869).
[7] Herrich-Schaeffer, Coord. Regensburg, XVIII, p. 177 (1864).

The revised edition of the "Butterfly Book" includes a reproduction of the Jones 'Icones' figure[8]. While the Fabrician description applies to it perfectly, both the picture and the description resemble the eight forms named below:

*Phyciodes quintilla* (Hewitson)[9].
*Heliconius clara* Fab.[1].
*Heliconius metaphorus* Weym.[10].
*Ithomia panamensis* Bates[6].
*Mechanitis macrinus* Hew.[11].
*Ceratinia azara* (Hew.)[12].
*Hypothyris philetaera* (Hew.)[13].
*Hypothyris megalopolis* (Fld.)[14].

Most of these can be eliminated promptly. The position of the cubital on the primaries in the Jones figure, as well as the lack of marginal dots on the secondaries precludes *P. quintilla*. *H. clara* has too many black median spots, while the marginal dots of the primaries are placed differently from the Jones figure. Also the cells of the secondaries of *Heliconii* are far shorter than the cell of the 'Icones' drawing. *H. metaphorus*, further, has a narrower black marginal area on the hindwing. *I. panamensis* differs in that there are always yellow streaks in the black apical region of the primaries, the marginal dots are white, those at the apex being far smaller than the analagous marks of the Jones figure. In *M. macrinus* the female resembles the Jones illustration, but the marginal black of the secondaries is narrower and the marginal dots at the apex of the primaries are fused into a streak. *C. azara* has three median black marks on the primaries, and a single large yellow apical spot, while the colors are greyer and more transparent than the opaque Jones figure. *H. philetaera* closely resembles the Jones figure, the secondaries and the marginal dots being nearly identical; but the distal edge of the yellow area is more irregular than the Jones figure, and is placed nearer the apex.

[8] Holland, op. cit., pl. LXXII, f. 2.
[9] Hewitson, Exot. Butt., V, p. 30; pl. XV, f. 23 (1872).
[10] Weymer, Ent. Zeit. Stett., XLV, p. 24; pl. 2, f. 1 (1864).
[11] Hewitson, op. cit., II, p. 29; pl. 15, f. 11 (1860).
[12] Hewitson, op. cit., 1, p. 26; pl. 13, f. 23 (1853).
[13] Hewitson, op. cit., V, p. 24; pl. 12, f. 230 (1875).
[14] C. & R. Felder, Reise Nov., Lep., III, p. 360; II, pl. 44, f. 9 (1865).

Also *philetaera* has three median spots which are sharply angular rather than roundish.

It will be noted that the above elimination is based on the assumption that the 'Icones' figure of *lycaste* is an accurate representation of the specimen which Fabricius called *lycaste,*—accurate with respect to pattern and wing shape.

There are before me six examples of *Hypothyris megalopolis* which are remarkably similar to the Jones drawing of *lycaste,* except for the body length, which Holland suspected was misdrawn[2]. This is the one point at which I am willing to concede inaccuracy on Jones' part, for the shape of the wings, the length of the antennae and such venation as is indicated in the figure certainly belong to an Ithomiine. In all of these respects, as well as in maculation and coloring. the figure agrees with *megalopolis.* One specimen, a male sent to me by R. Q. Bliss and collected July 11, 1937 at Ft. Kobbe, Panama Canal Zone (this example is now in the A. N. S. P. collection), is nearly identical with the Jones' figure. Of the six specimens, the one just mentioned has no trace of yellow, except the marginal dots, in the black apical area; the other five are marked only very slightly with tiny points of yellow, never approaching the large streaks of *panamensis.*

Because of this close agreement with the 'Icones' illustration, in addition to the fact that the Fabrician description fits, I am convinced that Fabricius had before him when he described *lycaste* an example of the form later described by C. and R. Felder as *megalopolis.* Consequently the Felder name falls as a synonym before *lycaste* Fabricius. Of the names applied to the group of forms which Reakirt wrongly associated with *lycaste, iphianassa* Doubleday and Hewiston[15] is the oldest and becomes the specific name.

[15] Doubleday, Hewitson & Westwood, Gen. Diurn. Lep., p. 127; pl. 18, f. 3 (1847).

# Current Entomological Literature

**COMPILED BY V. S. L. PATE, L. S. MACKEY and E. G. FISHER.**

Under the above head it is intended to note papers received at the Academy of Natural Sciences of Philadelphia pertaining to the Entomology of the Americas (North and South), including Arachnida and Myriopoda. Articles irrelevant to American entomology will not be noted; but contributions to anatomy, physiology and embryology of insects, however, whether relating to American or exotic species will be recorded.

This list gives references of the current or preceding year unless otherwise noted. All continued papers, with few exceptions, are recorded only at their first installment.

For records of Economic Literature, see the Experiment Station Record, Office of Experiment Stations, Washington. Also Review of Applied Entomology, Series A, London. For records of papers on Medical Entomology, see Review of Applied Entomology, Series B.

**Note.** References to papers containing new forms or names not so stated in titles are followed by (*); if containing keys are followed by (k); papers pertaining exclusively to neotropical species, and not so indicated in the title, have the symbol (S) at the end of the title of the paper.

**The figures within brackets [ ]** refer to the journal in which the paper appeared, as numbered in the list of Periodicals and Serials published in our January and June issues. This list may be secured from the publisher of **Entomological News** for 10c. The number of, or annual **volume,** and in some cases the part, heft, &c., the latter **within ( )**follows; then the pagination follows the colon :

**Papers published in the Entomological News are not listed.**

**GENERAL.—Anon.**—Entomological origin of the fleur-de-lis. [Ward's Ent. Bull.] 6, No. 5: 1. Department of Entomology. [Ann. Rep. Colo. Mus. Nat. Hist.] 1938: 39-40. Conseils pour la preservation des collections. [Lambillionea] 1939: 36-38. **Beckdorf, M.**—In den Pilzgarten der Atta. [Das Flussmeer] 1939: 62-74, ill. (S). **Britton, W. E.**—Additions to the check-list of the Insects of Connecticut. [Conn. Geol. & Nat. Hist. Surv.] Bull. No. 60: 169pp. **Carpenter, F. M.**—The lower Permian insects of Kansas. Part 8. [Pro. Amer. Acad. Arts & Sci.] 73: 29-70, ill. **Cockerell, T. D. A.**—Natural history of Santa Catalina Island. [Sci. Monthly] 1939: 308-318, ill. **Costa Lima, A. da.**—Insectos do Brasil. 1: 470 pp. ill. (K). **Debauche, H.**—Nouvelle méthode d'imprégnation des cellules nerveuses par le nitrate d'argent. [Ann. Soc. Sci. Bruxelles] 59: 23-27, ill. **Geary, N.**—Some habits of an assassin bug (Ptilocnemus femoralis). [Australian Mus. Mag.] 6: 351-353, ill. **Hatch, M. H.**—A bibliographical catalogue of the injurious arachnids and insects of Washington. [Univ. Wash. Publ. Biol.] 1: 163-224. **Hetrick, L. A.**—Preserve life history specimens in this gelatin-formaldehyde preparation. [Ward's Ent. Bull.] 6, No. 5; 4. **Holdhaus, K.**—Verschiedenartige Verbreitungsbilder unter den borealpinen insekten Europas. [Forsch. und. Fortschritte] 15: 81-83. **Holloway, J. K.**—An agar preparation for feeding adult parasite insects.

[12] 32: 154. **Hyslop, J. A.**—Giving meaning to the terms, brood and generation. [12] 31: 557-559. **Kurz, H.**—Opportunities for research in Florida [Proc. Fla. Acad. Sci.] 1: 7-16. **Lal, K. B.**—Parasitism in insects. [Current Sci., Lahore] 8: 55-59. **Martynov, A. B.**—Fossiles Insectes. [Trav. Inst. Paleontolog. Acad. Sci. USSR] 7: 7-80, ill. (Russian with English summary). **Maulik, S.**—A method of storing small specimens in alcohol. [Mus. Jour., London] 38: 570-574, ill. **Mohr, C. E.**—I explore caves. [Natural History] 43: 190-204, ill. **Nuttall, G. H. F.**—Obituary. By V. L. Yakimov. [Priroda] 1938, No. 11-12: 169-171. **Pough, F. H.**—The spider and the fly. [Natural History] 43: 220, ill. **Smith, R. C.**—Annual insect population records, with special reference to the Kansas Summary. [12] 31: 618-622. Some phases of entomological writing from the viewpoint of the reader. [12] 31: 563-565. **Swezey, O. H.**—Misidentity of immigrant insects in Hawaii. [Pro. Hawaiian Acad. Sci.] B. P. Bishop Mus. Sp. Publ. 33: 6-7. **van der Vecht, J.**—Het bewaren van insectenverzamelingen in de Tropen. [Ent. Med. Ned.-Indie] 4: 58-62, ill. **Vickery, R. A.**—Obituary. By O. I. Snapp. [12] 31: 637, ill. **Weiss & Carruthers.**—Insect enemies of books. [N. Y. Public Library] 1937: 63 pp., ill. **Whitehead, F. E.**—A proposed national contest for entomology students. [12] 31: 566-568.

**ANATOMY, PHYSIOLOGY, ETC.—Ancona, H. L.**—Histologia de la glandula venenosa de Crypsidromus breyerii. [Ann. Escuela Nac. Cien. Biol.] 1: 107-118, ill. **Balli, A.**—Longevita e perdita in peso negli adulti del Bombyx mori. [Mem. Soc. Ent. Italiana] 16: 115-123. **Becker, W. B.**—Larval development of the native elm bark beetle, Hylurgopinus rufipes in Massachusetts. [12] 32: 112-121, ill. **Berry, R. O.**—Observations on chromosome elimination in the germ cells of Sciara ocellaris. [Pro. Nat. Acad. Sci. U. S. A.] 25: 125-127, ill. **Chadwick, L. E.**—The axillary and subalar muscles in certain families of Lepidoptera. [Jour. Colo.-Wyom. Acad. Sci.] II: 47. **Debaisieux, P.**—Organes sensoriels de la tete d'asticots (Lucilia sericata). [Ann. Soc. Sci. Bruxelles] 59: 9-22, ill. **Debauche, H.**—See under general. **DeJong, J. K.**—The influence of the quality of the food on the egg-production in some insects. [Treubia] 16: 445-468. **Duncan, C. D.**—See under Hymenoptera. **Fischer-Wasels, B.**—Die Bedeutung der Erblichkeits-Faktors in der Geschwulstentwicklung. [Forsch. und

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